Nova Note # 1101, Version 2

Do we need Exterior End Gudgeons ?

Hans Jostlein 9/11/2006

Abstract
A simple way is shown to resist the peeling stresses between the extrusions and the bottom closure plates, without using an "exterior gudgeon".

Introduction

NOVA modules consist of lengths of multi-cell extrusions, capped at the top and bottom and filled with scintillating oil.
The caps must be oil tight. In particular the hydrostatic pressure at the bottom of the vertical extrusions is about 19 psi.
Bottom caps are designed almost completely with “captured glue joints” where the adhesive is stressed mainly in compression and shear.
The exception is at the edges of the extruded panels,
because it is desirable to install panels next to each other without a gap,
to create a uniform physics detector, and to cancel out fluid pressure forces on the outer walls of the last cells of each panel.

Solutions offered so far

A lot of ingenious work has been devoted to this problem.
One approach is RF welding, which can resist much larger stresses than epoxy bonding. This is under study.
A stronger adhesive such as DEVCON plastic welder can be used, but some more studies will be needed on ESH fumes issues and compatibility with the scintillating oil and other adhesives.
Another proposal (DocDB # 1090) is to capture all joints, with the disadvantage of creating a 10 mm gap between modules.

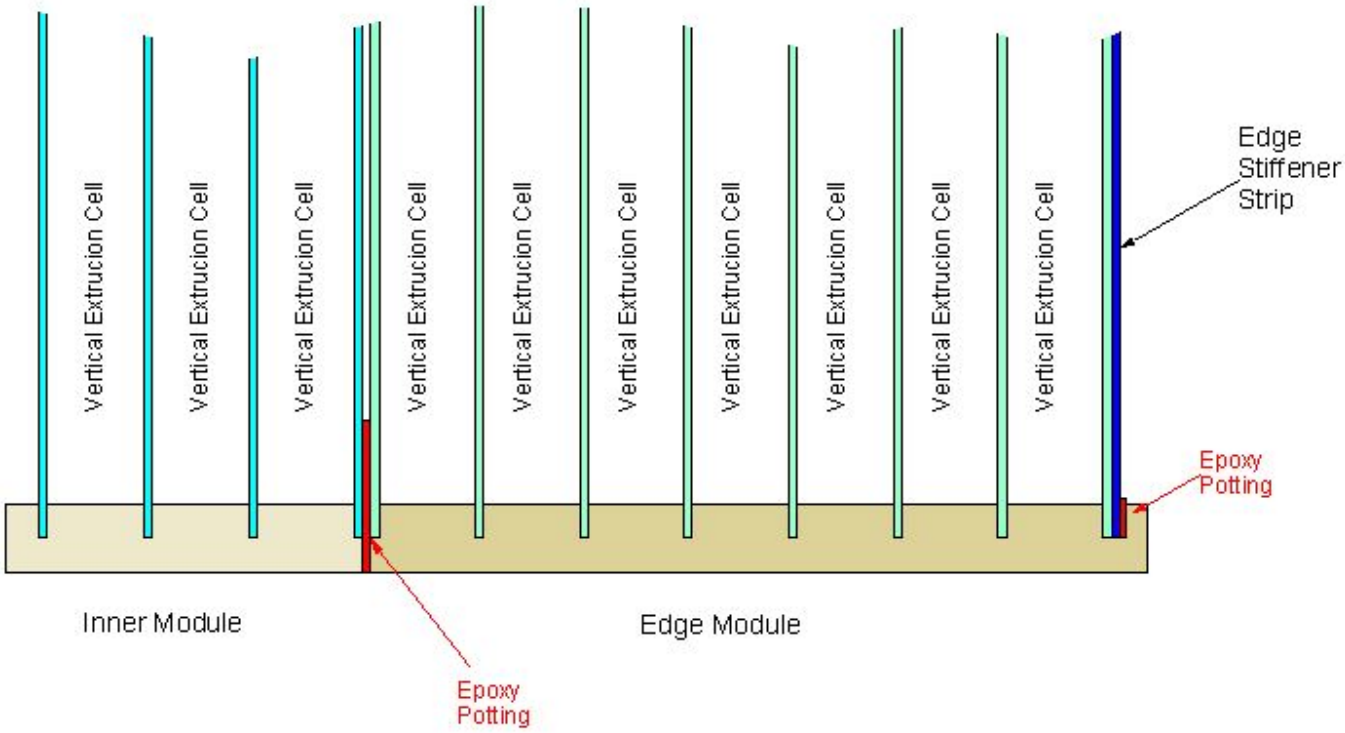
Let’s Define the Problem

The hydrostatic oil pressure tends to push out the outer walls of the edge cells.
This results in two concerns, i.e. the stresses in the outer wall itself, and the stresses in the bond from the outer wall to the bottom cap.
We will address the two issues now.

Benefits of “No Gap”

So far we had assumed that adjacent modules would be in close contact, or nearly so.
When the outer cell walls from adjacent modules bow out due to hydrostatic pressure they will soon contact each other and their hydrostatic forces cancel out.

(an aside: we need to quantify the maximum allowable air gap that protects the end walls from excessive stress).
The bottom cap area has special needs. The bottom cap itself is unyielding. If a small gap exists between adjacent modules, then stresses can concentrate in the end wall as well as in the glue joint between end wall and bottom cap. The stresses appear only after oil filling.
These stress concentrations can be completely eliminated if the gap between adjacent modules in the bottom cap area is filled with epoxy:



Cross section of two vertical extrusions

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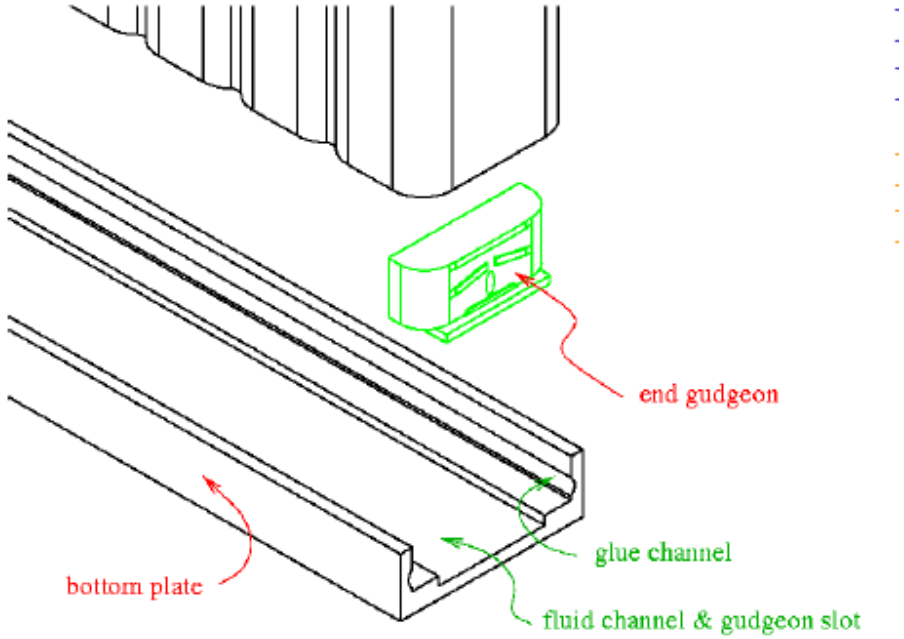
This can be done easily during layer installation. A small amount of tixotropic epoxy is smeared on the module edge near the bottom end, covering the bottom cap and a few inches of extrusion. This epoxy will be loaded in compression and acts essentially as a gap filler. The epoxy can have an extremely long pot life so as not to pace the assembly process.

The First and Last Module—a Special Case

The outer edges of the first and last modules are not protected by adjacent modules, hence see the full hydrostatic stresses. This has long been acknowledged, and lead to the adoption of a "stiffener strip" to resist this pressure.
The addition of the stiffener strip makes the end modules a little different form the interior modules. We propose to make them yet a little more "different".
The proposal is a slight modification of the bottom closure assembly.
The present design is described in NOVA note #1017 (Tom Chase and Alex Smith) :



It has an extruded bottom channel and end gudgeons.
For the outer edges of the end modules, we propose two small changes:

a. Extend the bottom channel out by about 8 mm
b. Route a short channel into the overhang of the bottom extrusion to accept the end of the stiffener strip.

We are, effectively, using the stiffener strip as an external gudgeon at this critical location.
This benefits both the joint between extrusion and bottom cap, and the joint between extrusion and the stiffener strip.

The routing can be done very quickly with a small wood router, mounted, e.g. on the base of a sliding miter saw, with appropriate fixturing and end stops.

Conclusion

External gudgeons and the undesirable gaps between adjacent modules can be eliminated by the simple process of:

a. Adding a little epoxy in the gap area around the bottom cap
b. Modifying the bottom cap for the end extrusions slightly.